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Surfacing Small Worlds through Data-in-Place

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Abstract

We present findings from a five-week deployment of voting technologies in a city neighbourhood. Drawing on Marres' (2012) work on material participation and Massey's (2005) conceptualisation of space as dynamic, we designed the deployment such that the technologies (which were situated in residents' homes, on the street, and available online) would work in concert, cutting across the neighbourhood to make visible, juxtapose and draw together the different 'small worlds' within it. We demonstrate how the material infrastructure of the voting devices set in motion particular processes and interpretations of participation, putting data *in place* in a way that had ramifications for the recognition of heterogeneity. We conclude that redistributing participation means not only opening up access, so that everyone *can* participate, or even providing a multitude of voting channels, so that people can participate in different ways. Rather, it means making visible multiplicity, challenging notions of similarity, and showing how difference may be productive.

Key Words

Community; data; data-in-place; digital civics; infrastructuring; material participation; small worlds; space; voting.

1 Introduction

The renewed interest in the 'smart city' and the relations between social life, technology and the urban built environment are giving rise to an increased concern for 'digital civics'. Public engagement and participation, democratic processes, and community building are all being considered with an eye on the role technology might play. In this paper, we draw on an extended empirical study of a city neighbourhood to show how the material and infrastructural underpinnings of urban technologies play into local forms of participation and engagement, setting in motion interpretations that are tied to ideas of commitment, alignment, and stability.

The basis to this work has two primary influences. First and foremost, it builds on prior work with the neighbourhood in question, reported by Taylor *et al.* (2015). Findings from household interviews, residents' meetings, deployments of sensors, and activities at a summer street party showed how the production and use of data in the neighbourhood is bound up with place, in terms of both physical and social geographies. Building on this, Taylor *et al.* proposed reconceptualising data as *data-in-place*, so as to acknowledge how relations between communities and their data are shaped by temporal and spatial boundaries inherent to the site of data production. Taylor *et al.* argued that these boundaries link the ways in which data flows into and through a multiplicity of 'small worlds' (Urry, 2004) and that these worlds are, reciprocally, tightly interwoven with the ways residents produce, understand and make use of data. Broadly, the notion of data-in-place presents an idea of data that is actively entangled in social and communal life, materialising in distinct ways, and in ways that matter differently to different parties.

A second influence centres on the relations between matter and place in civic and social life. This emphasis builds on an evolving body of work concerned with urban and civic settings that can be traced back to Dewey and de Certeau, and that is being developed by contemporary scholars like Urry (2012) and Massey (2005). As we'll show, of particular importance to us in this paper has been sociologist Noortje Marres' work in this area (2012). Like her predecessors, Marres recognises the normativities of participation and the corresponding distributed and fragmented nature of 'the public' (see de Certeau, 1984, and Mouffe, 2005). Her project is one in which participation is understood as an ongoing accomplishment, occasioned through ordinary and materially bound actions (Goodwin, 1999; Garfinkel, 1984). Thus, she builds on ideas of participation in which the always emerging relations people form with places and things fundamentally matter, shaping how people get to know each other and how consensus (or otherwise) is formed. What Marres does quite distinctively is foreground the productive capacities of what she refers to as technological devices of participation. She presents participation as inexorably entangled in the relations between people, places and things/technologies, and introduces a framework for us to think about how a heterogeneous public might intervene in the always contingent production of participation—ultimately, how people might affect some kind of change in their environments. This developing body of work, and Marres' orientation in particular, has then given us a well-articulated and theoretically-grounded position for both understanding and intervening in local forms of participation.

As we will show, the results of our work raise some critical questions about this orientation to local, civic life and its role in design and digital civics. The interventionist perspectives, as Marres and others have theorised them, are still largely propositions with few concrete examples. For now, let us say our work, on the ground, problematises how we should understand heterogeneity as it is manifest in local neighbourhoods, and thus, how we should seek to constructively engage the broader cross-sections of people who live together.

Before we develop these ideas further, we will present in more detail the literature we've drawn on in developing our thinking. We'll then describe our method, and present and discuss our findings. In the latter, we'll give specific consideration to urban technologies and the ways their design configure local forms of participation and engagement.

2 Related Work

In HCI and in CSCW there has been a growing concern for the entangled relations between the digital and social in urban and civic settings. Taking a critical stance towards the grander smart city visions, concerted effort has been put into better understanding urban (infra-)structures and organisation, and situating these within the wider and messier relations and flows intrinsic to modern urbanism (Williams and Dourish, 2006; Dourish and Bell, 2011; Dourish *et al.* 2007; Foth *et al.* 2011; Kukka *et al.*, 2014). Taking up these ideas have been a slew of more focused and pragmatic studies, concentrated on particular ways cities are inhabited for instance by commuters (Pritchard *et al.* 2015), and the issues that arise in urban and civic affairs such as planning and transport (Le Dantec *et al.*, 2015), air quality (Aoki *et al.*, 2009), and energy use (Bird and Rogers, 2010).

By looking to thicken our understandings of the relations between the civic and urban, the digital, and social life—the “*problems of participation*”, as Marres (2012) puts it—the work we present aims to build on these prior efforts. In particular, by extending how we might see the role for technology in local, collective and communal participation, it aims to make a contribution to those studies that have focused on community engagement. Where work has dealt, explicitly, with participation of this kind, it is clear that a host of problems can be encountered in relationships between the multiple stakeholders and the practicalities of instrumenting urban environments (Aoki *et al.*, 2009; Kukka *et al.*, 2014; Harding *et al.*, 2015).

A number of projects have been productive in both surfacing these problems and projecting possible alternative configurations. These endeavours intervene in and in some cases disrupt conventional forms of engagement, for instance, by using alternative forms of technology-mediated participation to encourage bottom-up or grassroots involvement from citizens (e.g., Taylor *et al.*, 2012; Le Dantec *et al.*, 2015). A recent example of this is reported by Koeman *et al.* (2015), who studied a busy street in Cambridge in the UK. A lightweight approach to community voting and data representation not only underscored divisions in the area, but also provided the basis for intervening in neighbourly encounters and promoting discussion. Still seeking to enable grassroots initiatives, but introducing more disruptive tools and processes, has been a handful of attempts to re-specify participation. Distinct here is that the proposals intend to refigure how participation is enacted in place and within communities: the vision is of a technological intervention that affords a deeper degree of social change, where citizens might come to understand their relations with place and citizenship differently. Vlachokyriakos *et al.*’s (2014) work on lightweight voting systems, which is detailed below and integral to the research we present, is one example of this. Another is reported by Crivellaro *et al.* (2015), who utilise a method incorporating instrumented city walks. Critical in this research is a theorizing of materiality in which the “*polyvocal*” in local political issues is materialised through talking and walking through the built environment. Practices involving the use of material things and movement through spaces are understood to play into the multiple trajectories that are constitutive of place and of collective engagement.

2.1 Infrastructuring and Material Participation

It’s these common concerns for multiplicity in participation, along with materiality and situated interventions, that draw us to the concepts of *infrastructuring* and *material participation*. Monteiro *et al.* (2013) describe information infrastructures as being characterised by: openness to different numbers and types of user; interconnections of modules or systems; dynamically evolving portfolios of systems; and as being shaped by an installed base of existing systems and practices. Because they are used across locales and for long periods, infrastructures necessitate a *standardisation* of practices by the people and organisations that interact with them, and must be *embedded* into often unrelated but already existing systems and infrastructures. Monteiro *et al.* argue that the work of building infrastructure is not about local activity, but about designing for activity that is distributed in time and space, and so must accommodate varying actors and multiple existing systems. This focus on infrastructuring as being about reconciling and bridging difference can also be seen in Neumann and Star’s (1996) early description; it is “*about mediating demands of multiple groups and making connections between them possible*” and, further, “*having a vision of where, in the future, all of these multiple trajectories will come together*” (p. 234).

Monteiro *et al.*’s focus is on cooperative work, and more broadly, the direction of the CSCW field. But when applied in non-workplace settings, the emphasis in infrastructuring tends to plurality. In her review of the work on infrastructuring in Participatory Design, Karasti (2014) notes that the open, dynamic and heterogeneous structures that make communities distinct necessitates a consideration of multiple voices. This can be seen in Le Dantec and DiSalvo’s (2013) analysis of two technology interventions in community settings. Their findings highlight how, while infrastructuring can draw individuals together to work for a common cause, it can alternatively support the formation of multiple ‘publics’ (following Dewey), which emerge as individuals coalesce around issues of note, taking different perspectives or finding alternative matters for concern, and therefore forming various alignments. Le Dantec and DiSalvo extend prior work to argue that infrastructuring is the work of creating resources for publics that are not anticipated; further to accounting for the multiple groups that are known, infrastructuring enables the discovery of unknown issues and underpins the constitution of unforeseen publics. Where civic engagement is the aim, Korn and Volda (2015) have proposed that provoking citizens to recognise and engage with difference can be productive. They argue for the creation of *friction* as a design strategy, identified through the development of a framework that intersects two dimensions for infrastructuring civic engagement. These are *everydayness* (following Lefebvre, 2014)—civic engagement

can be confined to ‘privileged moments’ (special activities that occur only infrequently) or experienced as part of everyday life (Lefebvre’s ‘product-residue’)—and *paradigms of political participation*—civic engagement can be consensual or contestational. Korn and Volda argue that friction, the provoking of contestation through use that is embedded in everyday life, holds particular promise. It brings infrastructures to the fore and, in doing so, compels citizens to reflect on and question the status quo. An instance of this is Clement *et al.*’s (2012) design of overlays for government ID cards, which allowed carriers to temporarily mask information exposed by default (such as one’s address) when there was no requirement for it (such as when buying alcohol, which necessitates only proof of age). Clement *et al.*’s study exemplifies the first of Korn and Volda’s design strategies for friction: intervening in infrastructures. Additional strategies include creating alternatives to facilitate a pluralism of voices, making gaps within and between infrastructures visible; and using trace data of infrastructural use to reveal or critique infrastructures.

The emphasis on community and participation in the research presented in this paper leads us to expand on the idea of infrastructuring as a means of supporting the formation and recognition of multiple publics. What we will aim to show is that infrastructuring is constituted through the collective work that always already comes with infrastructure. Infrastructuring here is more than the introduction of technologies and their capacities to enable publics (or indeed divide them). We seek to draw attention to an infrastructure-in-practice, how a technological machinery must be understood as part of a wider relational becoming with other entities and other traces. It is these unfolding processes between heterogeneous actors—this infrastructuring—that we see as affording and authorising certain kinds of collective living and differentiated forms of participation. In our approach we draw especially on Marres (2012), who, while not focused on infrastructuring, has emphasised the role of things or objects in the local production of ‘publics’. In her account of material participation, she aims to bring the wider problems of deliberative processes together with the situated and perfectly ordinary ways people and tools, devices, instruments, technologies, etc.—i.e., things—come to constitute the public and participation. With the former, the intention is to counter those philosophical formalizations of democracy and participation that rely on language as “*the central vehicle of politics*” (2011, p. 492) and that problematically define a polity *a priori*. The latter, building on a now long tradition in science and technology studies, represents a commitment to the normative capacities of things and, as such, how things *in situ* come to be entangled in and constitutive of particular social and political orderings (see, for example, Goodwin, 1994; Lynch, 1997; Latour, 1999). Together, these shift ‘the problem of participation’ to the capacities things have in holding together, ordering and animating matters of concern for the public.

The implication for Marres is an empiricist or experimental one:

“*One way to stop expecting that the problems of the material public are to be resolved by theoretical means is by turning our attention to the role that devices of participation play in the (dis-)articulation and (re-)distribution of these problems.*” (Marres, 2012, p. 59)

According to this view, the problem of participation lies in the relations between sites: in the procedures, vocabularies, settings and processes that materially mediate participation. Far from spaces of participation being defined independently from actual participatory processes, the enactment of participation is understood as entangled with the material organisation of participation. Marres argues that the nature of these participatory forms cannot be generalised; they instead reflect the evolving relations between publics and other actors, relations that are best understood as practical and material accomplishments. This is the basis for her assertion that:

“*Rather than trying to generate a conceptual map that can clarify this complex process of overlapping problematizations once and for all, it seems more worthwhile to explore problems of participation empirically.*” (Marres, 2012, p. 148)

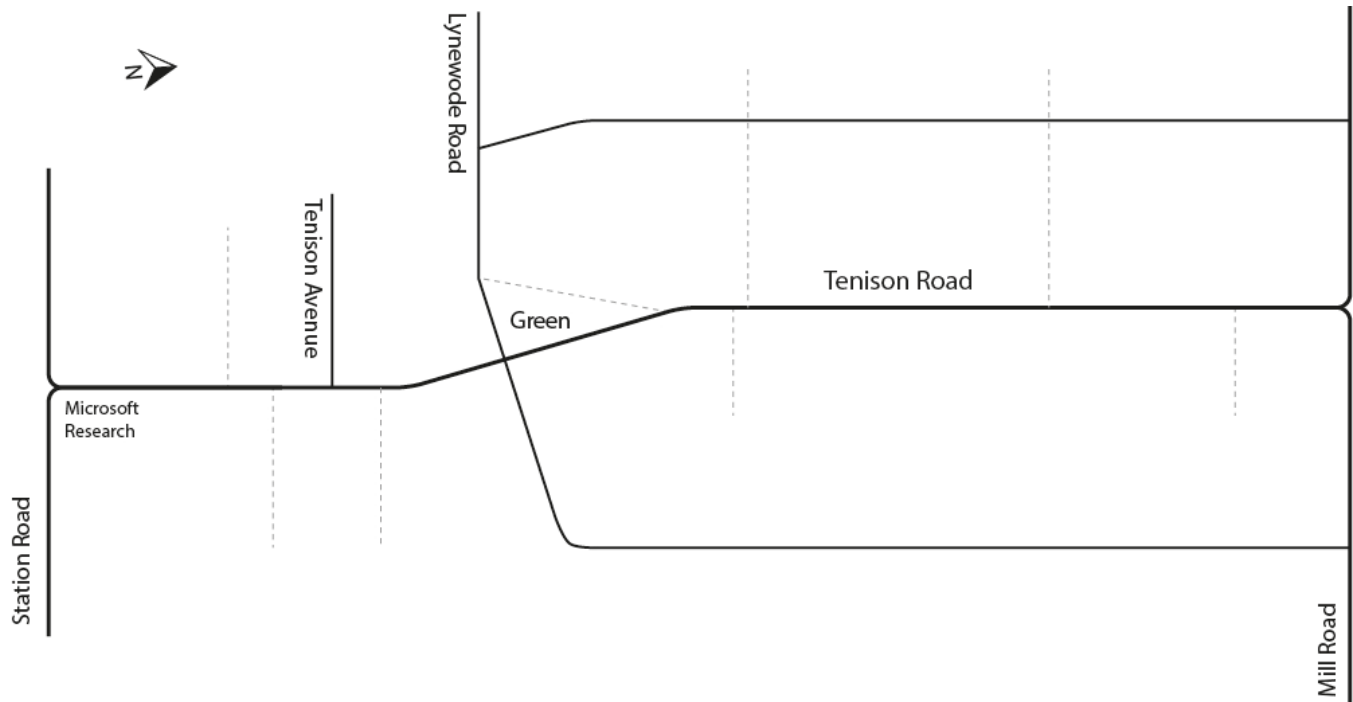
3 Motivation for this Research

The work we present here is an attempt to do just that: to explore problems of participation empirically, in a setting where the need to accommodate heterogeneity is recognised. We aim to do this through an intervention in which the processes that materially mediate participation, and their interrelations, are brought to the fore. In this section, we describe the setting for the intervention, how it built upon a longer engagement with a neighbourhood, and what the matters of concern were that had been highlighted by residents during that engagement.

The first twelve months of this longitudinal study have been previously described by Taylor *et al.* (2015). They describe the neighbourhood in question, which is nominally defined by Tenison Road, a largely residential street in the city of Cambridge, UK, on which our research lab is based. Tenison Road is approximately half a mile long and connects Station Road (and the railway station) with Mill Road (one of the more cosmopolitan and diverse areas within the city; see Figure 1). Our engagements with residents have demonstrated how they understand the character of the street to change across its length: a higher proportion of rental properties that are home to students and younger tenants are found towards Mill Road; families and owner-occupiers are more prevalent around the central Green; and small hotels and ‘bed and breakfasts’ are located nearer to Station Road. Taylor *et al.* argued that the neighbourhood comprises multiple ‘small worlds’, formed through an interplay of spatial, temporal

and social structures. Residents' encounters with one another are underpinned by their being present on the street at particular times, and by taking particular routes through it. This in turn is related to where they live on the street, and how their routines are framed by work, parenting, volunteering and leisure.

Figure 1. Schematic of Tenison Road, running from Station Road on the left to Mill Road on the right.



Our earliest engagements with residents, which spanned the period reported by Taylor *et al.*, were driven by monthly residents' meetings, taking place on weekday evenings at our lab. These were introduced at the project launch and managed by the research team through an email list. The launch, which was well attended, was publicised via the delivery of 100 invitations to properties on Tenison Road, and resulted in about 60 residents joining the project mailing list. The monthly meetings that followed were usually attended by 20-30 residents plus members of the project team. Topics for the meetings were chosen with the residents, but often related to the fostering of community and to major redevelopment works around the station, in which Tenison Road was heavily implicated.

These meetings might have cut across small worlds in the neighbourhood, offering as they did an opportunity for new encounters and, one might argue, the coalescing of a public around a set of common concerns (the redevelopment works being especially pertinent and wide-reaching in their impact). However, the meetings primarily attracted a certain demographic: owner-occupiers, who were typically parents and empty-nesters, and who lived in the area around and near to the Green. During meetings, the residents themselves noted that, as owner-occupiers, they had a different set of concerns to tenants or students, who were under-represented. They wished to include these groups because, firstly, the meetings often focused on the collection of neighbourhood data, and this necessitates engaging with residents across the neighbourhood, and secondly, addressing the perceived disconnect with certain sectors of the neighbourhood was seen as central to fostering community. Thus, the need for additional mechanisms of participation was recognised, which would cater to the heterogeneous nature of the neighbourhood, allow for multiple viewpoints, and open up possibilities to engage residents who were, at that point, less vocal, less present, and less apt to participate.

3.1 Research Aims

Accordingly, our aim in this research was to enable multiplicity by designing a technology intervention that would support alternative modes of participation, and to explore its relations with the material and situated qualities of the technologies we deployed. In Le Dantec and DiSalvo's terms, we might position this as infrastructuring; we sought to enable the coalescing of publics, either by drawing residents in to align themselves with the public already forming through the meetings, or by underpinning the development of (or perhaps simply making visible the existence of) publics that would align themselves to matters of local concern differently. By creating alternative technologies working in parallel, we aimed to intervene in the neighbourhood's trajectories and flows, and bring people (and perhaps publics also) together in new ways. Ultimately, we wished to

address the disconnect in the neighbourhood through the very act (rather than the outcome) of participating. Our approach draws inspiration from Massey's (2005) conceptualisation of space as a multiplicity of trajectories. For Massey, space unfolds on a moment-by-moment basis; it is "*an active reconfiguration and meeting up of practices and relations of a multitude of trajectories*" (p. 83). Positioning space as dynamic rather than static emphasises its potential to set off new interactions and relations, as new configurations of temporalities are brought into being. In this study, we position material devices as bound up with spaces of participation, recognising, as Dourish (2006) does, that technologies have the capacity to re-organise space.

4 Methods

The emergence of these research aims, of enabling multiplicity through material participation, and of drawing people together in new ways through the act of participating, required us to alter the mechanisms we had in place for data collection and engaging with residents. Consequently, towards the end of the first year of the research, we designed a study in which a number of devices, which were intended to work in concert, were deployed. While all of these had been presented at residents' meetings and also at a summer street party, only one had been deployed for the purpose of data collection (this was PosterVote, which had been used to collect data relating to a local traffic consultation). We complemented the deployment of these technologies with a change to the residents' meetings, adopting instead twice-weekly drop-in sessions for participants. In this section, we describe the technologies we deployed, the ways in which we attempted to facilitate the drawing of connections between them, and the ways in which we sought to understand their effects.

4.1 Technologies

4.1.1 Bullfrog

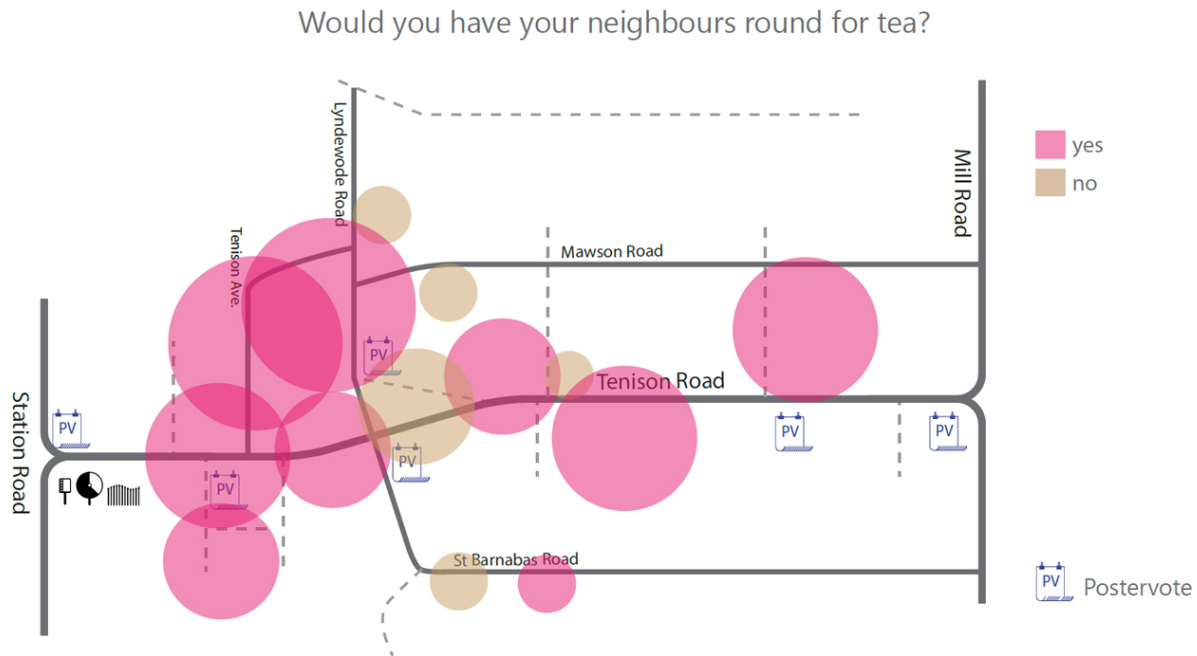
The first technology we describe, which was newly deployed for this stage of the research, is the Bullfrog (Figure 2a). Bullfrogs are small situated voting devices, previously described by Regan *et al.* (2015). They display questions, which were contributed by residents as well as the research team, and which can be answered through the insertion of a machine-readable paper card into the device. Possible answers are therefore constrained by the cards available. On reading the card, the Bullfrog displays a screen saying 'Thank you for your vote'. If multiple questions are available, they rotate, being shown for 5 minutes each. For questions that have been answered, the Bullfrog shows the text 'You voted! Revote?' underneath the question. Participants were instructed that only the last vote would count, and that they could override previous votes by inserting a new card.

For the purposes of this study, Bullfrogs were deployed in the homes of 33 local residents over a five week period. For the whole of this period, the question 'What is the mood in this house?' was presented every day. Typically, an additional new question was added from Tuesday to Saturday of each week. These asked about characteristics of the household and qualities of the neighbourhood. We encouraged participants to submit their own questions. Questions generated by residents included "How open to change is this neighbourhood?" and "When did you last chat on the street?". On Sundays no new questions were added, but all of the questions for that week remained visible. On Mondays, these were redacted and only the mood question was shown, while the research team analysed the data for the previous week. Results were delivered to participants in a weekly envelope, posted through their doors each Tuesday morning, along with any new voting response cards needed for the forthcoming week (Figure 2b). On two occasions during the trial, we also delivered Analytics cards, which presented patterns of data organised by location and insights into the temporalities of voting behaviours (e.g. Figure 3).

Figure 2. A Bullfrog (a), and the box it was deployed in with a results envelope (b).



Figure 3. An Analytics card.



The 33 households that took Bullfrogs (this was as many as we were able to build and deploy at the time) included regular meeting attendees but also students, couples and families who rented and owned properties in the neighbourhood, and who had not been involved in the project previously. We drew on interest expressed at the summer street party (which was very well attended) and through residents' meetings to recruit participants, as well as delivering 250 flyers to the neighbourhood, including to every household on the central street running through it, on the side streets coming off it, and on a relatively modern housing estate that is adjacent to it. This area encompasses parts of the neighbourhood noted as less connected to community by residents in earlier phases of the project, our aim being to include people who had not engaged strongly with the project up to that point in time. Participating households had from 1 to 6 members (average 3.06), comprising 54 females and 48 males in total, who ranged in age from 8 months to 74 years. The age range within a single household varied from 0 years (couples of the same age) to 49 years (average 24.24).

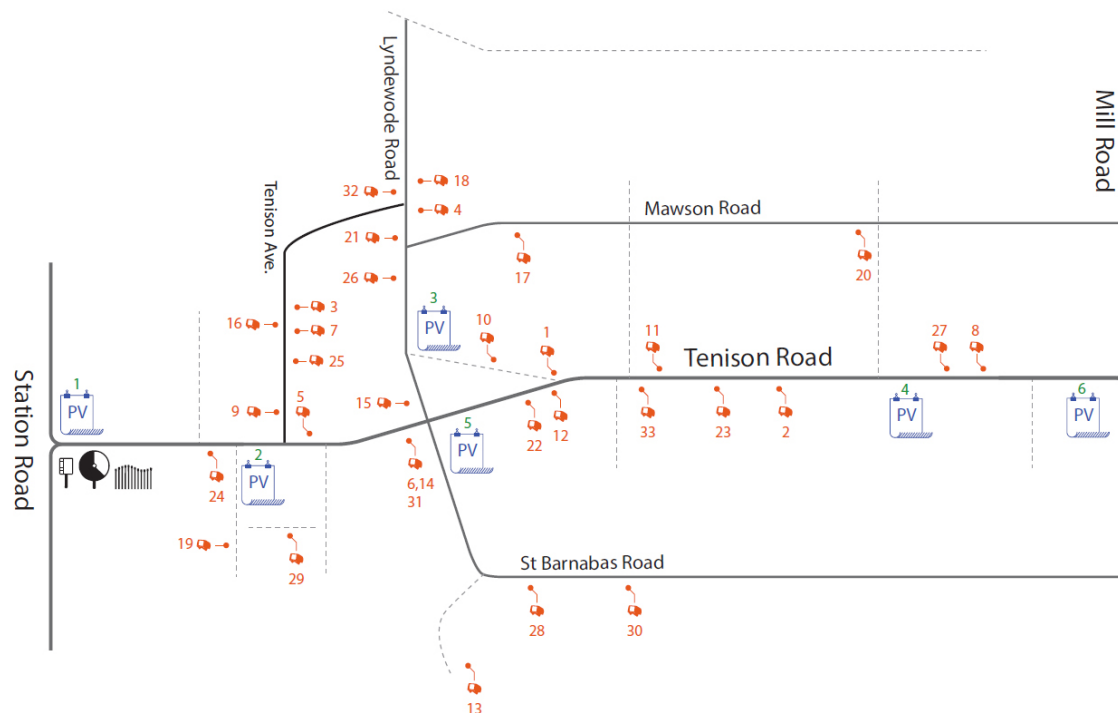
4.1.2 PosterVote

In addition to the Bullfrogs, six PosterVote posters (Figure 4) were deployed along the main road running through the neighbourhood. PosterVote technology, developed by Vlachokyriakos *et al.* (2014), augments physical posters so that they support push-button voting. In this study, the posters were laminated pieces of A3 paper that were mounted on acrylic and tied to lampposts. Three posters were positioned on each side of the road at focal points and places where people might linger (Figure 5). Posters were used to pose one new question for every week of the Bullfrog deployment. They were put up on Monday evenings and taken down the following Monday morning, after which the data was analysed. The questions that they displayed were also posed via the Bullfrogs, sometimes during the same week and sometimes, deliberately, out of sync. Results were displayed on posters too, sometimes of the previous week's PosterVote, and sometimes of a Bullfrog response to the same question. These points of crossover will be explained in more detail below.

Figure 4: Two PosterVote posters as deployed on the street.



Figure 5: Diagram showing approximate locations of Bullfrogs, PosterVote posters, and Physical Charts. Posters are sited near: the charts, the entrance to a housing estate, a youth hostel, a noticeboard, a pub, and the intersection with a local commercial street.



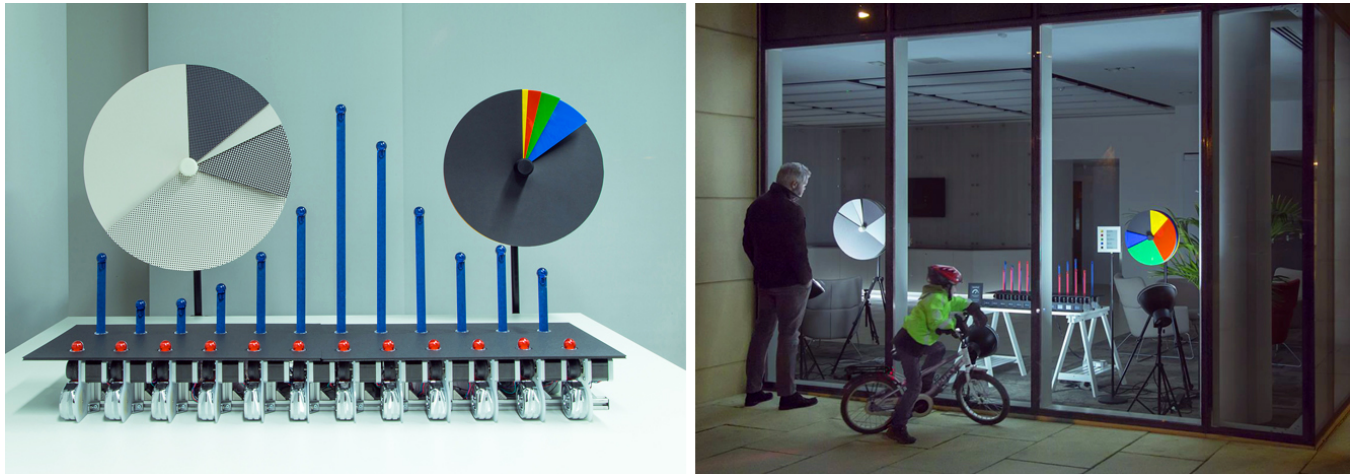
4.1.3 BallotShare and the Physical Charts

A final set of technologies are BallotShare and the Physical Charts (Figure 6a). The charts have also been previously presented by Regan *et al.* (2015). They are mechanically actuated pie charts and bar graphs, designed as a simple and playful response to the increasing sophistication of data visualisations.

The physical charts were displayed in the ground floor window of our building (Figure 6b), which is located within the neighbourhood, for the duration of the five week deployment of the Bullfrogs and PosterVote. They were presented alongside a question, which could be answered by visiting BallotShare, a voting website developed by Vlachokyriakos *et al.* (2014). The interface of BallotShare was adapted slightly and the back-end infrastructure altered so that it could accept votes made via Twitter and SMS. In addition to instructions for voting through these different mechanisms, passers-by who looked in at the Charts were presented with a QR code that could be used to visit BallotShare. The website URL, which was constant throughout the deployment, was also emailed to employees at the building where they were deployed.

The pie charts showed real-time results to the BallotShare daily questions (including votes cast using Twitter and SMS). These questions, posed from Monday to Thursday, were not connected to the questions asked via Bullfrog and PosterVote. On Fridays, a question about the neighbourhood was asked, which would remain in place until the following Monday morning. This question was the same as that shown (and still visible) on that week's posters. The results for this neighbourhood question was aggregated across PosterVote and BallotShare and presented on the bar graph from the Monday. If the same question had been posed using the Bullfrogs, the results would be juxtaposed with those from PosterVote and BallotShare.

Figure 6. The Physical Charts shown close up (a) and as visible from the street during the study (b).



4.2 Points of Connection

By deploying these technologies, which varied from playful situated devices to posters that could be quickly engaged with to online voting channels, we hoped to appeal to a broader range of residents than those who had been attending the residents' meetings. We also aimed to draw connections between users of the different technologies. The descriptions above point to some of the ways in which these connections were made, in terms of questions posed, presentation of results, and the potential for people to meet in person. In this section, we clarify how these connections were intended to tie in with our research aims, in other words, to intervene in a place's practices and flows, with the potential of bringing together trajectories that might not otherwise cross. Below we describe four types of connection: loops, in-person engagements, juxtapositions, and intersections.

4.2.1 Loops

The most straightforward type of connection in this study is the Loop. Loops enabled participants to learn about data gathered via the technologies that they themselves were using. For example, participants with Bullfrogs learnt about data gathered through the device via the weekly results envelopes. Similarly, voters using PosterVote could view the results by visiting the following week's posters, which had results from the previous week printed on them.

4.2.2 In-Person Engagements

We aimed to build upon Loops by opening up opportunities to underpin face-to-face encounters between participants, which could potentially support discussions about the data. We organised two weekly drop-in sessions for the Bullfrog participants, one every Wednesday morning at our lab, and one every Thursday evening at a local pub. We chose these different times to try to cater to people with different daily rhythms. Three residents attended a drop-in session: two came to separate sessions at

the pub and one came to two sessions at the lab. All were owner-occupiers and two had been regular attendees of the monthly residents' meetings. Two had Bullfrogs, the third came to express an interest in taking a Bullfrog and then to suggest a question. We also placed four *Pass It On* cards in a random selection of the Bullfrog results envelopes, with the request that the recipient insert it into their Bullfrog and then pass it to another person they knew with a Bullfrog. Additionally, the posters and Physical Charts could serve as foci for discussion and thus support in-person engagements.

4.2.3 Juxtapositions

We also designed data displays to juxtapose results, so as to make visible different orientations to the questions. We did this both within and across devices. A within-device juxtaposition was presented using the Bullfrog Analytics cards (Figure 3), which made prominent certain temporal and spatial features of the results (i.e. at what times during the day or night people voted, and how the votes were physically distributed across the neighbourhood). Cross-device juxtapositions drew on data collected using Bullfrog, PosterVote and, at times, BallotShare. For example, we asked questions via Bullfrog and PosterVote out of sync, in order to highlight the findings from one at the point of asking the same question via the other. This emphasised the responses of those who had used the alternative technology, and put participants in the position of considering whether their views were aligned with them. The Physical Charts also juxtaposed responses to the neighbourhood questions, such that votes cast by people using Bullfrogs were compared with those cast by people using PosterVote and BallotShare.

4.2.4 Intersections

Our ultimate aim was to draw together the people producing data, and to do so across technologies. We therefore designed a number of intersections across technologies. We placed Special Cards in plastic envelopes behind the posters, which could be used to answer the daily mood question posed on Bullfrog (these allowed playful responses to be made, such as 'bah humbug' and 'wicked'). The existence of these was advertised in the weekly results envelope, in the hope that they might encourage Bullfrog participants to visit the posters, and in doing so take a different route through the neighbourhood, become more aware of the overlap between questions asked on Bullfrog and through the posters, or even engage with someone voting via the posters. We also designed the Physical Charts to provide something of a spectacle, which could potentially attract participants using any of the technologies and again, open up different trajectories through the street.

4.3 Data Collection and Analysis

While we did, of course, collect data via the voting technologies, in this paper we focus on what we learned of the experience of participating in the study. We interviewed members of 14 households using Bullfrogs, between the third and fifth weeks of the deployment. Four interviews were with multiple household members, while the remaining 10 were with individuals, often those who had served as a point of contact for the household during the deployment. In total, this sample comprised 5 males and 15 females, ranging in age from 10 years (one of the interviews was with a mother and her two children) to 69 years. Nine of these households had not been involved in the study prior to the Bullfrog deployment, six were living on side streets off the main road and three were located in areas reported to be less connected with the overall community in prior engagements (Taylor *et al.*, 2015).

The interviews were held in participants' homes, enabling us to see where the Bullfrog was positioned and to discuss with participants how this impacted its use. The location of the home also framed questions about the broader ecosystem of voting technologies in the study (i.e. PosterVote and the Physical Charts), and whether participation had grounded discussions with other participants and residents. Through the interviews, we sought to understand how participants felt about the voting technologies and the data they returned. We explored how voting was organised within the home, how participants interpreted the data that was delivered in the results envelopes, and whether they felt they had learnt anything new about their home or neighbourhood through their participation. We also asked what participants thought the data should be used for, and by whom. This latter was framed in part by the redevelopment works impacting the area; we were interested in whether and how participants felt the technologies should play a role to effect local change. Finally, we enquired whether they would like the project to continue beyond the intended five weeks, and if so, what our role in that should be.

The interviews were audio recorded and transcribed in full. Open codes were assigned to interview transcripts and then relationships between them developed through axial coding (Corbin and Strauss, 2008). Axial codes include: attentiveness to neighbourhood, alignment with neighbourhood, performativity through data, reflection, having a voice, dialogue, and control. Three higher level themes were produced: material participation, dialogue, and multiplicity and negotiation.

5 Findings

In this section, we give a brief overview of use of the voting technologies, before presenting interview findings in relation to the three higher level themes just described.

5.1 Use of Voting Technologies

Bullfrog was used relatively consistently over the five week deployment, with the exception of the final week, which ran over the Christmas holiday (only 82 votes were cast this week, in comparison to 157 the week before, and 162 on average across

the five weeks). 60 questions were asked during the deployment and 810 responses generated, with an average of 13 votes per question (*min* = 4, *max* = 27). Daily mood questions were responded to less frequently (9 households on average) than questions asking about household or neighbourhood characteristics, which participants could respond to over the course of the week (20 households on average).

The six PosterVote posters, which presented a single question for each of the five weeks, generated 791 votes in total, ranging from 127 to 178 votes each week. For BallotShare, a total of 348 votes were cast during the study, ranging from 6 to 57 votes per week in response to 1 to 5 questions posted online.

Special Cards were collected from all six posters and used a total of 14 times by five households. Only one of the Pass It On cards was transferred, being used by two households.

5.2 Participating via Bullfrog

In the Methods section, we described a process that was designed to acknowledge multiplicity and reconfigure trajectories such that they might be brought together in new ways, either through the juxtaposition of sets of data or the literal coming together of individuals. Through our interviews with Bullfrog users, we explore the experience of a diverse sample of local residents, whose participation was managed principally through a material voting device that was located in their homes, but who had access to (and were encouraged to utilise) the additional technologies that were deployed. Here, we reflect on how our attempts to foreground the role of place, and of material infrastructures, were bound up with the ways that data was perceived and understood. We organise our findings in terms of the three categories that emerged in our analysis: material participation, dialogue, and multiplicity and negotiation.

5.2.1 Material Participation

Participation as Community-Oriented

Firstly, participation in the deployment was interpreted as community-oriented, and this was intrinsically linked to the fact that voting was grounded in the context of the neighbourhood. For instance, Wendy (all participants are given pseudonyms), a mother of teens, described how the neighbourhood is characterised by *“a lot of people who live their lives rather closed (...) they get up, they go to work, you don’t go and say hello or anything.”* She noted, *“What’s quite nice about the Bullfrog is you get up, you read what your neighbours are up to, you do something with the community, you vote and then you go out”*. Voting via Bullfrog provided a lightweight but unequivocally material way of participating along with one’s neighbours, and supported this routinely in an environment where habits involving one’s neighbours are difficult to establish. As Wendy suggests, its physical presence in the home played into this, linking participating households through a common procedure and corresponding view of the results. Also notable in Wendy’s account is the notion that the collective act of participation is as important as the data that it produces. This was a constant thread in the interviews: for Nancy *“the value of the project [is that] it suggests to people and reminds them that we can be a community”*; for Gwen it was an opportunity *“to be part of something”*; and for Sally it was a *“heartening”* indicator that others are *“up for doing this kind of thing”*. The material infrastructure that linked the act of voting to one’s neighbours transformed it into an expression of community spirit.

Community as Homogeneous

The simple act of voting then, was seen as doing something with others in the community. This seemed consolidated further by participants’ assumptions of who their fellow Bullfrog users were; while they were largely unaware of who else had a Bullfrog, their suppositions were of a homogenous group. For example, Ursula described the participants as *“a self-selected group of people who proclaim themselves to be interested in this project by choosing to take the Bullfrog”*. Willingness to be involved in the project was taken as an indication of like-mindedness.

Expectations of homogeneity were perceived as receiving support from the data produced by the Bullfrogs, even though for many questions a diverse sets of answers were given. Samantha, who rents in the area, noted, *“it’s interesting seeing the trends and how there’s so many similarities. It’s just not a very miscellaneous group of responses. There’s general trends in almost all the results which is really interesting”*, and Gwen described how *“there are a lot more like-minded people than I initially thought”*. Further, a sense of alignment was apparent in Gwen’s interpretation of the analytics cards, from which she drew an impression of being temporally affiliated with other participants, despite the fact that the rhythms of her everyday life had changed quite dramatically and very recently, following the birth of a child:

“...not that I ever get a lie-in anymore, but I definitely do (start the day) later, at weekends, because things are just a little more quiet and a little bit more sedate. So, yes, this is really interesting (...) to see that you almost do follow the similar pattern. Apart from these individuals! (Points to information about people who voted at midnight.) So, yes, I really like that.” – Gwen

While Gwen recognises that not everyone who is participating is the same as her, and indeed highlights those who vote at midnight as distinct, the emphasis is on similarity. This emphasis carried through even for participants who felt that they were not in alignment with other respondents. In observing “*how ridiculously unlike my vote all these other ones are*”, Ursula conveyed that she was the only one that was different; she was the exception that proved the rule.

For the Bullfrog users at least, the material infrastructure bound up with the study underpinned an idea of homogeneity. Despite the fact that Bullfrogs were deployed across diverse sectors of the neighbourhood, they played into a sense of being in alignment with others. While this supported the sense of acting with the community, it obviously ran counter to our research aim of acknowledging multiplicity by making visible different responses and different temporal and spatial voting patterns.

5.2.2 Dialogue

The Fixity of Existing Viewpoints

The previous section illustrates how, despite our aim to enable the expression of multiple viewpoints, the overriding impression participants took from the Bullfrog deployment was one of a homogeneous group enacting their shared commitment to community. Here we demonstrate that, even where heterogeneity was recognised, it was taken as supporting existing views of the neighbourhood, with students and those living in buy-to-let houses seen as less involved in community efforts (see also Taylor *et al.*, 2015). For example, the spatial Analytics cards, which presented maps of responses, were seen as upholding, rather than challenging, the view that there is a weaker sense of community as one gets closer to Mill Road, where renting is more prevalent. These maps, which tended to indicate a lower response rate in this area (see Figure 3 for an example), were taken as demonstrating a lack of commitment to the project by people living there, and by extension, to matters of community more generally.

This perceived lack of commitment was indeed explained by interviewees as being related to the higher number of rental properties in that part of the neighbourhood; renting being associated with high turnover and therefore less need and opportunity to be involved in local matters. We were surprised then, when an explanation citing transient populations was also offered when an Analytics card showed participants living in a more central area—typically described as stable and community-oriented—had disproportionately voted ‘no’ to the question, ‘Would you have your neighbours round for tea?’. Sally, an owner-occupier, put this down to “*more turnover of people in that little section there than there is round the rest of it*”. Because the data, and the identities of the Bullfrog users more generally, were anonymous, participants did not know exactly who had voted ‘no’ to this question, or whether they had indeed recently moved to the street or were neighbours with people who had. What was apparent though, was that the data did little to challenge existing views of the street:

“I don’t think I’ve learnt this from – what I’m telling you is what I thought before. It hasn’t changed my view. Nothing I’ve learnt has changed my view of the neighbourhood.” – Isabelle, owner-occupier and long-term resident

Thus, a lower commitment to community continued to be associated with transience, and a lack of investment in community was interpreted as present in the areas where residents expected to find it, despite data that could be read as suggesting something different.

Opportunities for Dialogue

This lack of challenge to existing views may be partly due to the lack of dialogue occurring around the data that was produced. Opportunities for meeting other participants in person (e.g. at the pub or office drop-ins) were poorly attended, and interviewees described how they were more likely to discuss responses within their own homes, rather than with other local residents. For example, the question, ‘Would you have your neighbours round for tea?’ turned out to provoke a good deal of discussion within households, leading to reflection on existing behaviours and values. Patricia, a mother of young children, commented:

“It makes you think actually. There was a question about would you invite your neighbour over for a cup of tea. That got me and my husband talking quite a bit. I’m sure it would have done the other households as well and maybe will prompt people over Christmas because we were like, “Well we should. We should get a couple of people over,” and hopefully we will.”

In another household, the question was seen as carrying complex moral connotations. One of the mothers we interviewed spoke about how she felt it essential to answer this question in a particular way, one that was shaped by recognition of what was ‘right’, rather than being an accurate statement of whether the household were in fact likely to have their neighbours round:

“Well I had been completely absent from the vote about whether you would have your neighbours around for tea, but my husband and my daughter had a discussion and then he had decided it wasn’t important enough that he was going to overrule it, whereas I felt really differently. I felt it was the wrong answer and absolutely she needed to be overruled, or persuaded that we should argue it until she comes to the right decision. In retrospect, of course, that’s ridiculous, but I do think morally there are certain things that it needs to be the right decision and they need to learn what the right decision is. That’s partly what

being a parent is I hope, whereas it was interesting that my husband just was quite happy to, you know, and again we had a discussion about that too.” – Rebecca

The above indicates how discussion around Bullfrog votes could elicit self-reflection and contemplation of what the ‘right’ type of response might be. However, while differing viewpoints were exposed and discussed within homes, dialogue rarely extended outside of this context. Several participants described a need for richer dialogue than the technologies supported, but only three attended a drop-in session. It is possible that the need for dialogue is in conflict with a desire to avoid confronting issues in a face-to-face context. Indeed, even where participants knew one another and were aware of their mutual participation, they did not view it as appropriate to discuss their votes. Isaac noted the difficulty of discussing how one votes, even with a friend: *“Well I don’t discuss how I answer but on one occasion I did say, What do you think of it altogether?”*, and Patricia spoke more generally about the difficulty of touching on potentially contentious issues with neighbours:

“I have felt powerless to be able to gauge other people’s reactions about (a new zebra crossing), even to the point of which I don’t feel I can really ask my neighbours about it.”

As Marres (2012) and Latour (2004; 2005) have demonstrated, material forms of participation make possible very particular forms of dialogue and indeed authorise particular kinds of publics. In the same way, what we see here is that a material infrastructure designed to promote heterogeneous participation is at once implicated in a moral set of questions. The configurations of hardware and data networks, of where to vote and the ways to vote, of a street and its demographic cartography, and so on, draw residents into normative judgements of participation, of participating in ways that are right or wrong. For Rebecca, the household vote afforded by the Bullfrogs comes with certain responsibilities around what must be collectively communicated, whereas for Isaac and Patricia, voting in the domain of the home sets limits on what rights people have to the results. Participation infrastructures are active, lively even, in how we come to participate. Participation doesn’t merely overlay an infrastructure, but comes into being through it.

5.2.3 Multiplicity and Negotiation

Resisting Multiplicity

The above begins to point to a normative dimension to the material infrastructures of participation, of the sorts of things that can and can’t be expressed through particular structures and in/outside of the confines of one’s home. These material forms of expression and participation were achieved not just in responding to questions broadcasted using the Bullfrogs but also in posing the questions. Residents could (and did) suggest questions to be asked via the distributed infrastructure, and in doing so worked with it to gauge reaction and raise awareness to specific issues. Wendy noted that even being on the other end of this process highlighted *“what other people might think of as local issues, which you may not think of as an issue”*. Yet, again, there were limits to this. We found that the reluctance to raise controversial issues was also felt when posing questions, although for a different set of reasons. For example, Isaac, a retired owner-occupier, had initially intended to propose a vote about experiences of local traffic. He eventually decided against doing so, however, expressing concern over the implications of individuals voting primarily to register concerns about the specific roads they lived on:

“I didn’t realise, when I came to you, how sensitive the traffic issue is going to be because of these different roads having different wishes; it’s actually much more sensitive than I thought then.”

Expanding on this point, he noted:

“They don’t want the question asked because it might undermine their position. You might say it’s ‘NIMBY’ (Not In My Back-Yard), which of course it is, and we all suffer- I’m not saying I don’t have NIMBY motivation but you don’t really want your ‘nimbyism’ to be undermined. (...) So if you get a survey that actually goes against your wish you’ll be sorry you had anything to do with the survey. (...) It’s easier to sit in your own house and think everybody agrees with you, but they don’t, that’s for sure.”

Isaac chose to avoid proposing a question that could reveal results in conflict with his personal hopes for the area. Opening up discussion to the wider neighbourhood introduces the possibility of engaging those who may disagree with his point of view. Implicit in this is the position that data is collected with purpose but once gathered can be used by others, and to other ends. We might say here that the infrastructures of participation and how they were materialised in practice, brought into being a specific form of data and its collection, but also an authority to the data. In Isaac’s case, we see that with the wide distribution of questions come answers that have weight, that count numerically and as a sign of collective conviction, both of which can undermine an individual’s position. The material infrastructuring, then, comes to authorise a format or structure to participation and what counts. Sometimes, one might try to circumvent or avoid this infrastructuring when matters are sensitive, and people may not agree.

Multiplicity is Implicit across Devices

Yet, while interviewees highlight the difficulty of talking about how one votes and the risk of being counted against, there was a feeling amongst Bullfrog users that alternative viewpoints were represented through the wider technological infrastructure we manufactured. Wendy described the posters as supporting “*a wider spread of the community voting*”, and Claire, an owner-occupier and parent, commented:

“The posters are going to get a different demographic, particularly here because we’re on the main cycle and walking route between the city centre and the station, so it’s going to have a lot of people who aren’t residents stopping and looking.”

Furthermore, the multiple technologies were often referred to as providing channels of ‘communication’ that could potentially involve different groups:

“It is a way of communicating, like having the whole community involved with one project, that is, it is sort of involving everyone, so everyone has a vote and has a voice and can see what happens.” – Eleri

“I can see the benefit of it is that you’re opening up opportunity to people to contribute and understand in as many different ways as possible, so it’s about widening dimensions of it so it is convenient to people in different ways. (...) I think having the variety of means of both collecting it and communicating it is important.” – Sally

While the Bullfrogs were believed to signify a homogeneous and community-oriented group, it was assumed that other sectors would interact with PosterVote and BallotShare. The positioning of the different technologies was understood, rightly or wrongly, to enact not just a physical, but also a social geography to the neighbourhood, where different kinds of people were seen to reside and move. Residents seemed sensitive to how place comes to be, as Massey (2005, p. 10) has phrased it, “*a product of interrelations*”, and, as a consequence recognised the capacity for a mixture of infrastructures to ‘widen dimensions’, to intervene in the ongoing “*throwntogetherness*” (ibid., p. 141) of place.

Barriers to Shifting Trajectories

Yet, just as the Bullfrog participants knew few other residents who were using Bullfrogs, they encountered few users of PosterVote and BallotShare. Only a minority of participants noted that the technologies worked in concert, and offered the potential to interact with other residents about the data being gathered. These exceptions included Wendy, who commented, “*One thing I thought was quite nice is having the letter envelope things behind the posters to kind of get Bullfrog and poster to mix*”, and Claire, who said, “*And actually I did bump into people standing outside and looking at the funky graphs. And they weren’t necessarily Bullfrog users. It was colourful and eye-catching and people were stopping and looking*”.

However, participants (including Claire) also expressed the view that having access to a Bullfrog meant that they did not need to use PosterVote. She reflected, “*It almost seemed like, if you had a Bullfrog the posters didn’t really do much because you’d already done it, as it were, with the Bullfrog*”.

Further, the potential to find Special Cards at the posters, or view results displayed on the Physical Charts, was acted upon by only a minority of Bullfrog participants. Most participants simply did not encounter the posters when taking their usual routes through the area, and seemed reluctant to change their habits to accommodate them. So while Isabelle expressed making “*an effort to come down (the main road) sometimes*”, as opposed to taking her usual, alternative, route through the neighbourhood, she was in the minority. Gwen, who had received one of the Pass It On cards, emailed the research team to say that she did not know anyone to pass it on to, and was advised to put it behind one of the posters. However, even this was problematic:

“I haven’t walked down that way yet with the dog, so I’ve still got hold of it (...) We have our routines in the mornings and the evenings of where she goes on her walks. We head out that way because it’s just a bit quieter.”

Walking with a pushchair and dog meant that Gwen preferred to walk through the neighbourhood in a particular way, a route that did not include Tenison Road, or any of the project’s posters. It was no easier to alter the habits of other residents; spatial and temporal boundaries remained as barriers to both engaging with multiple devices and moving through the neighbourhood in different ways. The intervention of installing technology infrastructures was simply not sufficient to disrupt existing practices. Infrastructure may indeed entangle in the ongoing production of space (and its heterogeneity), but it seems quite another task to shift or change the flows and trajectories in order to support a richer and deeper flourishing of multiplicity. To do as scholars like Marres and Massey invite and use technologies to intervene in participatory practices, it seems the infrastructures and the practices afforded and authorised by them—the infrastructuring—must find ways of being deeply entangled in shifting trajectories, not just from above or below, but binding into the structures of communal life and social geography.

6 Discussion

The aim of this research was to consider how to enable participation that allows for multiplicity, and to examine how the material and situated qualities of devices, and the infrastructures they form, play into this. Would the technologies we deployed

enable publics to coalesce, by drawing residents into a public that had formed through residents' meetings in relation to local redevelopment issues and a desire to foster community? Would they aid the formation of additional publics, who might orient to these matters in alternative ways or have different concerns? Could the technologies, working in concert, facilitate interactions and new encounters within the neighbourhood, drawing together distinct trajectories in new ways? Our findings indicate something of the challenge these aims present, and in doing so, highlight some of the complications we believe are inherent to material participation and infrastructuring for community engagement.

6.1 Multiplicity and Material Participation

Our analysis demonstrates that use of Bullfrog was associated with an imagined idea of a broadly homogenous community, with other data infrastructures being perceived as associated with different groups, who were perhaps less vested in community or had other relationships with the street, such as experiencing it only as part of a commute. Responses that challenged this assumption, such as the data that was produced in response to the question about having one's neighbours round for tea, were either not seriously engaged with or explained away. This notion of homogeneity had two consequences for the ways in which participation was understood. Firstly, it seemed to largely exclude the idea that those renting might be included in the results, and so contributions by this demographic to the Bullfrog data went *unrecognised*. Secondly, it meant that the different views expressed within the data were largely subsumed in a broader narrative of *alignment and similarity*.

6.1.1 Recognising Participation

That participation may go unacknowledged is obviously problematic. In the neighbourhood under study, it raises a particular set of difficulties because commitment to community was seen to be bound up with the act of participation. Indeed, the act of voting via a Bullfrog was as consequential, if not more so, than the results of the votes. This resonates with Dewey's conception of engagement, cited by Marres, where the actual efforts people make provide a more adequate expression of their engagement with public affairs than 'what they say about it' (2012, p. 62). This study shows how different perceptions of investment—of having a Bullfrog in one's home as opposed to voting using a poster on the street—played into interpretations of data and the people who are assumed to produce it. Participants with Bullfrogs felt themselves to be members of a public, a membership that was made material through their use of the devices and their infrastructure rather than being grounded in alignment to a common cause. Indeed, contributions from students and tenants that may have challenged existing viewpoints were instead made invisible through their aggregation with the responses of others. This raises the question of how we might design technologies to make visible the presence of minority viewpoints as distinct from others yet on equal terms with them.

6.1.2 Ideals of Alignment and Similarity

The subsuming of multiple perspectives into a broader narrative of alignment and similarity ties into ideals of community, and raises a separate set of issues. Participants have told us that members of their neighbourhood hold multiple, and potentially conflicting, views; however, their desire seems to be for alignment. So while our strategy of infrastructuring could have facilitated a pluralism of voices and perhaps even the creation of friction (Korn and Volda, 2015), we found instead that participants looked for homogeneity, sought to 'fit in' and resist confrontation, and avoided posing questions that might provoke dissent. This may have particular resonance with *neighbourhood* participation; positioning space as dynamic, fluid and changeable does not sit easily with aspirations for a coherent community. As Massey puts it: "*There can be no assumption of pre-given coherence, or of community or collective identity. Rather the throwntogetherness of place demands negotiation (...) politics is the (ever-contested) question of our being-together.*" (2005, pp. 141-142)

The question we raise here is how this prerequisite for negotiation might be given more prominence in an arena of digital civics, and indeed how the ever-contested questions inherent in 'being together' might be understood not as confrontational or antagonistic but more as a productive force in 'working community out'. Following Marres (2012), a deeper working *with* the capacities of participation technologies seems to be what is demanded. As we've shown, for Marres, the specific capacities afforded through different technologies play into distinctive formats for participation—through ever-shifting relations between settings and technologies, the participatory body is continually performed. Yet, in our work, the technologies and their infrastructures appeared, if anything, to perform publics and the participatory body or bodies along established trajectories. Beyond categorising the results for each technology and visualising them in different ways, there was little to convey how the different types of participation were not just different in number, but surfaced a varied texture to participation that couldn't be treated uniformly. Furthermore, we invited few opportunities for thinking about how these differences might allow for a mixture of trajectories in the neighbourhood, thereby producing a variation in participation, and necessarily constituting a more textured and indeed fluid character to community.

It seems the data infrastructures operated at a distance from participation. Yes, they gave people an idea of their capacities for varied participation, but at the same time detached them from actively and materially engaging in infrastructuring, in exerting some agency in the flows of data. This raises the challenge of how, in practice, we might design data technologies that reveal their capacities for agency and their distinctive ways of formatting or enacting participation. A significant challenge here would

be to show how the infrastructures are not solutions for differences to be somehow resolved or discounted, but offer (and indeed are unavoidably a part of) the ongoing production and organisation of communal life.

6.2 The Role of Place

In exploring the possibility that voting technologies could work to intervene in the neighbourhood's trajectories, bringing them together in new ways, our findings indicate resistance. Part of this can be put down to the difficulty of shifting routines; we undoubtedly overestimated the likelihood that people would change their movements in response to our interventions, or indeed the extent to which they would participate in activities with others in the neighbourhood. Drawing on prior work on infrastructuring, we might relate this inertia to the notion of the installed base (Star and Ruhleder, 1996). The installed base typically refers to established technologies, such as the internet, upon which innovations are built; indeed, in this study too the internet played an important role in underpinning the technological infrastructure that was put in place. In addition to this, however, roads, pavements and lampposts formed the backdrop to the deployment of PosterVote, and houses and the rooms within them shaped the deployment of Bullfrog. This 'installed base', if you will, foregrounded a different type of inertia to that which is usually described in studies of infrastructuring, but one that played an important role here. Korn and Volda (2015) have suggested that intervening in infrastructures is one way of designing to create friction. In our case, the intervention was not sufficient to shift participation that was grounded in an infrastructure of physical place.

It is worth also noting that place played an additional role in relation to the lack of dialogue. Residents were reluctant to discuss how they had voted, even with their friends, and were unwilling to broach potentially contentious issues with their neighbours or instigate data collection that might open debate. This suggests a perhaps more general problem for creating friction in hyperlocal settings: publics may seek to avoid its generation. This reluctance to pose questions seems tied to how a sense of homogeneity is cemented, and it highlights the challenge of putting data *in* place. As we have seen, data-in-place can bring with it normative expectations and assumptions that have already been forged. Yet place is relevant. Findings might, for example, be read differently if they simply indicate that all respondents highlight their own street as being in need of reduced traffic. The broader question this raises is how we can design to re-direct the trajectories of data that run through a place, encouraging dialogue, whilst allowing for fluidity and allowing new, and perhaps unexpected, publics to emerge.

It is here in particular that we feel the bringing together of Marres' and Massey's work is productive. Recognising, as Marres does, that publics are materialised in distinctive ways through technologies of participation, and understanding space to be always at stake in "*contemporaneous multiple becomings*" (Massey 2012; p. 120), we see infrastructuring as something that binds participation and space together and, crucially, offers a means of interjecting in this relational unfolding. The more or less intransigent alignments and resistances we saw among the residents point to our participation technologies and their infrastructures not offering sufficient openness to space and its becoming. Through our technological and infrastructural intervention, we expected participation and the space it was bound up with to change, but at the same time we limited what capacities people had to interject in that change. In short, we separated participation from the work of infrastructuring. A challenge is raised here, then, for ways of actively involving collectives in the *infrastructuring of participation*—not just participation itself—so that we might allow for the differentiated textures and trajectories of space-making that Massey calls for.

7 Conclusion

Studies of participation often focus on its enablement or encouragement. However, and as has been argued by Le Dantec and DiSalvo (2013), infrastructuring must go beyond enabling participation; it must allow for the coalescing of a public or publics. In this paper, we have described an attempt at infrastructuring, an attempt that placed pluralism and the bringing together of trajectories at its core. Yet, while we did enable participation, we cannot claim to have seen a public, or publics, coalesce through our intervention. Instead, and in support of Marres' theorising on material participation (2012), we observed how the material qualities of an infrastructure gave shape to distinct forms of participation. These forms, rather than intervening in how citizens understand their relations with place and citizenship, were instead understood as surfacing small worlds that were already assumed to have a presence in the neighbourhood. Thus, our attempts to give voice to the neighbourhood's multifaceted elements were challenged through perceptions and interpretations of participation, which were in turn bound up with the material ways through which it was enacted. Similarity was associated with the adoption of a common means of participating, while multiplicity went unrecognised and was even resisted through a reluctance to pose questions that could underpin confrontation or make visible diverse viewpoints.

At the heart of this struggle has been, we believe, a problem of infrastructuring. If we take infrastructuring to be a technical business of building technologies and the structures that connect them, our project certainly represents an instance of such work and the role it can play in (re)producing publics. However, it's our assertion that the interventions we designed with the neighbourhood in question neglected the ongoing work of infrastructuring. To have some genuine impact, infrastructuring must be a collective enterprise, entangled with unfolding mixtures of heterogeneous actors. It cannot be cast from the outset or somehow operate above or below people participating in communal life. Intervening in and redistributing participation then, requires not only opening up access, so that everyone can participate, or even creating alternatives, so that people can participate in different

ways. A redistribution of participation necessitates an infrastructuring that draws people into the structural configurations of heterogeneity, and shows how making a difference can come to count.

8 References

- Aoki, Paul M., R. J. Honicky, Alan Mainwaring, Chris Myers, Eric Paulos, Sushmita Subramanian, and Allison Woodruff. (2009). A vehicle for research: using street sweepers to explore the landscape of environmental community action. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09), Boston, USA, 4-9 April 2009*. New York: ACM Press, pp. 375-384.
- Bird, Jon, and Yvonne Rogers. (2010). The pulse of Tidy Street: Measuring and publicly displaying domestic electricity consumption. In *Pervasive 2010 Workshop on Energy Awareness and Conservation through Pervasive Applications, Helsinki, Finland, 17-20 May 2010*.
- Clement, Andrew, Brenda McPhail, Karen Louise Smith, and Joseph Ferenbok. (2012). Probing, mocking and prototyping: participatory approaches to identity infrastructuring. In *Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1 (PDC '12), Roskilde, Denmark, 12-16 August 2012*. New York: ACM Press, pp. 21-30.
- Corbin, Juliet and Anselm Strauss. (2008). *Basics of Qualitative Research* (3rd ed.). Newbury Park, CA: Sage Publications.
- Crivellaro, Clara, Rob Comber, Martyn Dade-Robertson, Simon J. Bowen, Peter C. Wright, and Patrick Olivier. (2015). Contesting the city: enacting the political through digitally supported urban walks. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 2853-2862.
- De Certeau, Michel. (1984). *The Practice of Everyday Life*. Berkeley: University of California Press.
- Dourish, Paul. (2006). Re-space-ing place: "place" and "space" ten years on. In *Proceedings of the 2006 20th anniversary conference on Computer Supported Cooperative Work (CSCW '06), Banff, Canada, 4-8 November 2006*. New York: ACM Press, pp. 299-308.
- Dourish, Paul and Genevieve Bell. (2011). *Divining a digital Future: Mess and mythology in ubiquitous computing*. MIT Press.
- Dourish, Paul, Ken Anderson, and Dawn Nafus. (2007). Cultural mobilities: diversity and agency in urban computing. In C. Baranauskas et al. (eds.): *Proceedings of the 11th IFIP TC 13 International Conference on Human-Computer Interaction (INTERACT '07), Rio de Janeiro, Brazil, 10-14 September, 2007*. Berlin Heidelberg: Springer, LNCS 4663, Part II, pp. 100-113.
- Foth, Marcus, Jaz H-J Choi, and Christine Satchell. (2011). Urban informatics. In *Proceedings of the ACM 2011 conference on Computer Supported Cooperative Work (CSCW '11), Hangzhou, China, 19-23 March 2011*. New York: ACM Press, pp. 1-8.
- Garfinkel, Harold. (1984). *Studies in Ethnomethodology* (2nd rev. ed.). London: Polity Press.
- Goodwin, Charles. (1994). Professional vision. *American Anthropologist*, vol. 96, no. 3, pp. 606-633.
- Goodwin, Marjorie H. (1999). Participation. *Journal of Linguistic Anthropology*, vol. 9, no. 1/2, pp. 177-180.
- Harding, Mike, Bran Knowles, Nigel Davies, and Mark Rouncefield. (2015). HCI, civic engagement & trust. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 2833-2842.
- Karasti, Helena. (2014). Infrastructuring in participatory design. In *Proceedings of the 13th Participatory Design Conference (PDC '14), Windhoek, Namibia, 6-10 October 2014*. New York: ACM Press, pp. 141-150.
- Koeman, Lisa, Vaiva Kalnikaitė, and Yvonne Rogers. (2015). "Everyone is talking about it!": a distributed approach to urban voting technology and visualisations. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 3127-3136.
- Korn, Matthias, and Amy Volda. (2015). Creating friction: infrastructuring civic engagement in everyday life. In *Proceedings of the Fifth Decennial Aarhus Conference on Critical Alternatives (AA '15), Aarhus, Denmark, 17-21 August 2015*. Aarhus University Press, pp.145-156.

- Kukka, Hannu, Johanna Ylipulli, Anna Luusua, and Anind K. Dey. (2014). Urban computing in theory and practice: towards a transdisciplinary approach. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational (NordiCHI '14), Helsinki, Finland, 26-30 October 2014*. New York: ACM Press, pp. 658-667.
- Latour, Bruno. (1999). Circulating reference: sampling the soil in the Amazon forest. In *Pandora's Hope: Essays on the Reality of Science Studies*, pp. 24-79. Harvard University Press.
- Latour, Bruno. (2004). *Politics of Nature: How to Bring the Sciences into Democracy*. Harvard University Press.
- Latour, Bruno. (2005). From Realpolitik to Dingpolitik or how to make things public. In Latour, B. and Weibel, P. (eds) *Making Things Public: Atmospheres of Democracy*, pp. 14-43. MIT Press.
- Le Dantec, Christopher A., and Carl DiSalvo. (2013). Infrastructuring and the formation of publics in participatory design. *Social Studies of Science*, vol. 43, no. 2, pp. 241-264.
- Le Dantec, Christopher A., Mariam Asad, Aditi Misra, and Kari E. Watkins. (2015). Planning with crowdsourced data: rhetoric and representation in transportation planning. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15), Vancouver, Canada, 14-18 March 2015*. New York: ACM Press, pp. 1717-1727.
- Lynch, Michael. (1997). *Scientific Practice and Ordinary Action: Ethnomethodology and Social Studies of Science*. Cambridge: Cambridge University Press.
- Marres, Noortje. (2012). *Material Participation: Technology, the Environment, and Everyday Publics*. Palgrave Macmillan.
- Marres, Noortje and Javier Lezaun. (2011). Materials and devices of the public: an introduction. *Economy and Society*, vol. 40, no. 4, pp. 492.
- Massey, Doreen. (2005). *For Space*. London: Sage.
- Monteiro, Eric, Neil Pollock, Ole Hanseth, and Robin Williams. (2013). From artefacts to infrastructures. *Computer Supported Cooperative Work*, vol. 22, no. 4, pp. 575-607.
- Mouffe, Chantal. (2005). *On the Political*. Psychology Press.
- Neumann, Laura J., and Susan Leigh Star. (1996). Making infrastructure: the dream of a common language. In *Proceedings of the Participatory Design Conference (PDC '96), Cambridge, USA, 13-15 November 1996*. Computer Professionals for Social Responsibility, pp. 231-240.
- Pritchard, Gary, John Vines, and Patrick Olivier. (2015). Your money's no good here: the elimination of cash payment on London buses. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 907-916.
- Regan, Tim, David Sweeney, John Helmes, Vasillis Vlachokyriakos, Siân Lindley, and Alex Taylor. (2015). Designing engaging data in communities. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 271-274.
- Star, Susan Leigh, and Karen Ruhleder. (1996). Steps toward an ecology of infrastructure: borderlands of design and access for large information spaces. *Information Systems Research*, vol. 7, no. 1, pp. 111-134.
- Taylor, Alex S., Siân Lindley, Tim Regan, David Sweeney, Vasillis Vlachokyriakos, Lillie Grainger, and Jessica Lingel. (2015). Data-in-Place: thinking through the relations between data and community. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15), Seoul, South Korea, 18-23 April 2015*. New York: ACM Press, pp. 2863-2872.
- Taylor, Nick, Justin Marshall, Alicia Blum-Ross, John Mills, Jon Rogers, Paul Egglestone, David M. Frohlich, Peter Wright, and Patrick Olivier. (2012). Viewpoint: empowering communities with situated voting devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12) Austin, USA, 5-10 May 2012*. New York: ACM Press, pp. 1361-1370.
- Urry, John. (2004). Small worlds and the new 'social physics'. *Global Networks*, vol. 4, no. 2, pp. 109-130.
- Urry, John. 2012. *Sociology beyond societies: Mobilities for the twenty-first century*. Routledge.

- Vlachokyriakos, Vasilis, Rob Comber, Karim Ladha, Nick Taylor, Paul Dunphy, Patrick McCorry, and Patrick Olivier. (2014). PosterVote: expanding the action repertoire for local political activism. In *Proceedings of the 2014 conference on Designing interactive systems (DIS '14), Vancouver, Canada, 21-25 June 2014*. New York: ACM Press, pp. 795-804.
- Vasilis Vlachokyriakos, Paul Dunphy, Nick Taylor, Rob Comber, and Patrick Olivier. (2014.) BallotShare: an exploration of the design space for digital voting in the workplace. *Computers in Human Behavior*, vol. 41, pp. 433-443.
- Amanda Williams and Paul Dourish. (2006). Imagining the city: the cultural dimensions of urban computing. *Computer*, vol. 39, no. 9, pp. 38-43.